Possible use of geophysical methods in exploration for Pb-Zn deposits in Kosovo

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The principal role of geophysical prospection is to understand the physical features of rocks and minerals. Application of electric and electromagnetic methods is successfully used in prospection of Pb-Zn sulphide deposits. Different rocks exhibit different values of electrical resistivity. The sulphide ore is characterized with low resistivity that stands out from the surrounding rocks.

Base-metal deposits in Kosovo are of particular value. The lead-zinc deposits have been extracted since pre-Roman times. Actually the lead-zinc ores are extracted and processed by Trepça Mining Complex. Trepça, as well as several other companies are presently the holders of prospecting concessions. The whole area has a high prospection potential, because of the fact that in the last years a few new mineral occurrences have been discovered. The recent political stabilization in Kosovo provides good conditions for carrying out field research, including the application of modern geophysical surveys.

Overall site investigation and knowledge about regional geology plays the key role in successful prospection. The Pb-Zn deposits in Kosovo are located within the Vardar Zone (Schumacher, 1950; Hyseni *et al.*, 2010). The metallogenesis was related to Tertiary calc-alkaline volcanism activities.

Stan Terg, the largest Pb-Zn deposit in Kosovo, is of metasomatic-hydrothermal origin (Palinkaš *et al.*, 2013). The ore bodies are hosted by schists and carbonates, on a contact with volcanic rocks. Principal ore minerals are pyrite, galena, sphalerite, whereas minor minerals are pyrrhotite, arsenopyrite, marcasite, chalcopyrite, as well as many other sulphides and sulphosalts. The gangue minerals are calcite, quartz, dolomite, and rhodochrosite. The ore is mainly massive and coarse-grained.

The other known lead-zinc deposits of Kosovo, like Novo Brdo, Hajvalia, are characterized by similar features. Kizhnica and Crnac deposits are related to serpentintes. All the Pb-Zn deposits in Kosovo are mainly replacement deposits in carbonate rocks, sometimes skarn occurs. Veins and veinlets, paleokarst fillings, ore lenses, disseminated sulphides are also common.

The suitability of the application of different electrical and electromagnetic methods in the Stan Terg deposit area has been considered. Among these methods are the direct current method (DC), induced polarization (IP), time-domain electromagnetic (TEM), and audiomagnetotellurics techniques (AMT). The last two of them may allow investigating also greater depths. The Stan Terg deposit is open towards the depth, and the length of the deposit is also uncertain, therefore the study of deeper rocks plays a key role in prospection.

Modeling by the IX1D software has shown benefits of investigation by each considered method and also limitations of them. The forward modeling problem has been solved. Layered geological model and values of physical parameters have been selected. Finally, the obtained synthetic data for each method have been compared.

The chosen geological model comprises layers of carbonates, schists, volcanic, volcano-sedimentary rocks, as well as sulphide ore. Orebodies are located between carbonates and volcanics. They are lens shaped. The resistivity and polarization values have been set as in the laboratory measurements done by Korolija (1980).

Carbonates and volcanics show the highest resistivity; and also the other rocks have rather high values of this parameter. The ore is characterized by approximately the same value of resistivity as schists and volcano-sedimentary rocks (about 300 ohmm), what is greater than typical (30 ohmm). Therefore two models with different ore resistivity have been considered, with resistivity values of 300 ohmm and 30 ohmm, respectively.

The relatively high value of ore resistivity could be caused by picking up not representative samples for measurements, by high content of sphalerite in the investigated samples, by mistakes during the measurements or because of using outdated equipment.

Last but not least, the time of polarization was set. The sulphide ore stands out with long time of polarization (30 ms), whereas the other rocks are characterized with values lower then 10 ms.

The result has proved how large the influence of resistivity value of the ore is. The identification of orebodies is possible only when they strongly stand out with low resistivity. If the resistivity of ore is only about 30 ohmm, we can observe a resistivity anomaly and its contrast towards the surrounding rocks. Then the surrounding rocks have similar resistivity values that may cause difficulties in distinguishing the borders between ore and non-mineralized rock.

The high resistivity of rocks is a limitation for time-domain electromagnetic technique. Good results have been obtained by modeling for DC, IP and AMT methods. The AMT method should be used to identify physical features at greater depth, to a few kilometers, what is sufficient for mining and economic geology purposes.

In the Stan Terg area the successful geophysical survey may be conducted only if the ore is of low resistivity. Otherwise the measurements will not give satisfactory results and it will not be possible to uniquely identify the orebodies.

Properly conducted electrical and electromagnetic surveys in Kosovo may be helpful for carrying out base-metal prospection and to indicate the optimum sites for drillings. However, the key is first to perform accurate laboratory measurements, to see the physical characteristics of the studied rocks.

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